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Business models of young firms operating in renewable energy technologies: innovation strategies and context perception [1]

Abstract

This paper focuses on the behaviour of new technology-intensive firms (NTIFs) in the process of developing research-based renewable energy technologies, and introducing them into the market.

Our main assumption is that the introduction of new energy technologies is closely connected with the creation of a variety of small technology-intensive firms that are the conveyors of these technologies and act as challengers to the statu quo.

We adopt a business model framework to study value creation by NTIFs, taking into account the context, where policy options, obstacles and opportunities impact the action and outcomes of the companies. The framework is applied to a group of 28 Portuguese NTIFs in several renewable energy areas.

Further work will explore the potential both of the conceptual and analytical frameworks introduced here, and the array of interesting data collected in the research.

Keywords: new technology-intensive firms; business models; emerging renewable energy technologies; socio-technical transitions.

JEL Codes: 030; Q55; Q20; M21

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1. INTRODUCTION

This exploratory paper focuses on the behaviour of new technology-intensive firms (NTIFs) in the process of developing research-based renewable energy technologies, and introducing them into the market, thus contributing to the transition to a low carbon regime. It tries to identify the main business models adopted by these companies during that process.

Compared to previous major shifts, the current transition contains important specificities: the overwhelming inertia of the prevailing energy socio-technical system or techno- institutional complex (Geels, 2004; Unruh, 2000); and the urgency to decrease carbon dependency, assumed by public powers and supported by organized social groups and a significant part of public opinion.

These two aspects have given rise to the setting of ambitious goals and the implementation of novel public policy devices at European and national levels. A European strategy for energy and sustainability was launched in 2007 aiming to stir technological innovation, the formation of new markets and the set-up of novel coordination schemes.

Our main assumption is that the introduction of new energy technologies is closely connected with the creation of a variety of small technology-intensive firms that are the conveyors of these technologies and act as challengers to the statu quo (Bergek et al, 2008; Hekkert and Negro, 2009). This is because the exploitation of technologies that break-up with established technological regimes requires new knowledge and entails a high degree of uncertainty, thus creating opportunities for new entrants (Brown et al, 2007).

These new firms (and sectors) – which are often spin-offs from research organizations and large companies -, exploit advances in several scientific and technological domains and take advantage of the opportunities created by the new political and policy framework. Although facing huge obstacles, they have benefited from an array of incentives to renewables and from the creation and development of new markets (like those connected to biofuels, energy efficiency, buildings certification, and so on).

The transition literature is mostly focused on the macro level (regimes) (Markard et al, 2012, for a survey). It addresses small firms' strategies from the view point of regime shift. NTIFs either engage in alliances within the dominant regime (hybridization); or develop radically new and divergent technologies (and products) in niches (niche accumulation) (Raven, 2007; Smith, 2007). These new energy technologies have reached different levels of maturity and market acceptance, implying different levels of opportunity for new firms (Hockerts and Wüstenhagen, 2010). Such sources of heterogeneity suggest that we will find distinct types of NTIFs.

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We adopt a business model framework (Huijen and Verbong, 2013) to study value creation by NTIFs, taking into account the context, where policy options and a set of obstacles and opportunities impact the action and outcomes of the companies. The framework is applied to a group of 28 Portuguese NTIFs in several renewable energy areas. Data were collected through detailed interviews, based on a semi-structured questionnaire, with the founders or the CEOs, complemented with an extensive search for documentary information on the firms.

Based on the detailed information obtained, the analysis of the cases permits to identify: 1) the main opportunities and barriers that small companies have to face; 2) the existence of distinct behaviour forms according to two main analytical dimensions: business strategies and innovation strategies; 3) the impact of the recent turn in public policy, with the halting or decrease of most public incentives to renewables.

The results, which are analysed in light of the extant theoretical and empirical literature, may give insights into the role(s) played by NTIFs exploiting new energy technologies in the regime shift. They are also expected to contribute to further the knowledge about this emerging sector and to provide policy contributions.

We intend to develop this work on further analyses, in order to explore the potential both of the conceptual and analytical frameworks introduced here, and the array of interesting data collected in this research.

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2. CONCEPTUAL FRAMEWORK

Small firms exploring and/or creating in a successful way entirely new technology have to deal with the problem of succeeding in the commercialization of their product or technology. Survival and development of those companies depend as much of their knowledge, creativity and productive abilities as of their capacity to design and implement adequate strategies to enter and sustain a position in the market.

This is even truer for firms in renewable energy areas that are, most of them during a period, working out of the dominant technological trajectories, that is, the dominant technological regime. In fact, they face the inertia and hardness of a strong installed socio-technical system, made of a complex of dominant technologies, powerful incumbent companies, large and dramatically costly infrastructures, vested interests' organizations, historically built consumer preferences, outdated policy options and installed routines (Unruh, 2000). In addition, the new technologies are usually cost ineffective at the start-up and early stages, when it comes to compare their price performance to the one of the dominant technologies they wish to substitute. In a way, they are confronted with the (rival technologies) dilemma pointed out by David (David, 1985).

In order to survive and thrive in their innovation undertaking, the new technology-intensive firms have to design and adopt an adequate business model (BM), whose two main pillars are the most important challenges they face: value creation and value capture. The business model concept appeared in the 1970s but it was not until recently that it gained momentum. The spread of the use of Internet put at stake some industries, like music records and video sale and rental, not to mention film distribution and exhibition itself. On the other hand, it permitted the creation of new modes of business, like e-commerce. For both reasons, necessity and opportunity, the Internet stirred new forms of conceiving and carrying on business, that is, originated new business models, addressing the need to monetize Internet applications or to take advantage of new commercial opportunities. Examples of the former are e-Tunes and offerings that combine free access to basic products – software and others - and pricing for upgrades or adds-on. An example of the latter is E-bay, Amazon, e-travel sites and many others. In such cases, innovation concerns the new business model itself.

This concept has been adopted by innovation studies, particularly when dealing with new complex technologies developed in parallel (or in niches, according to the transition literature), with the dominant regime. This means far more than putting together commercial and productive strategies, although the concept comprises both.

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Two recent comprehensive critical surveys (Zott et al, 2011; Klang et al, 2010) proceeded to a clarification of the domain, although recognizing that shortcomings and inconsistencies still subsist in the use of the concept.

The final definition proposed by Zott el al (2011:18-19) is the following: the business model is characterized as a new unit of analysis (closer to the firm or closer to the network); resorting to a holistic and systemic perspective; integrating activities (including boundary-spanning activities from the view point of the focal firm); and where the notion of value is central, both in regard to creation and capture. The main dimensions retained are then: value creation; value capture; organization of internal and bound-spanning activities of the firm; product market strategy; and obstacles and opportunities faced by the focal business.

This approach is much in line with Teece (2010), who writes that a business model describes the "design or architecture of the value creation, delivery and capture mechanisms employed" (Teece, 2010: 191). Some aspects of Teece´s elaboration are to be retained, both contextual (the customer power has increased, it is not just a question of the shifts in the customers habits and practices, associated with the spread of the Internet; and intangible markets have grown) and internal (discovery, learning and adaptation are intrinsic to business models).

As to Klang et al (2010), they provide an approach to the business model concept that stands on three pillars: *classification; components and configuration*. Their approach draws on semiotics and chooses to study the syntactical dimension of the BM, defined as the relation of the BM with other same level theoretical categories (or signs), that is, concepts like strategy, value chain positioning, and so on.

Beginning with *classification*, and based on the reviewed literature, the authors draw a line between strategic management theories (mainly concerned with the understanding of value capture) and BMs, which are more focused on value creation (Klang et al, 2010:8). Another important difference being that strategy is more concerned with firm´s "positioning vis-à-vis its competitors" (Klang et al, 2010:9), while BM puts an emphasis on "the patterns of its economic exchanges with external parties" (Klang et al, 2010:9). But in fact "despite these differences, the BM concept builds on ideas advocated by the main theoretical frameworks of business strategy, strategic management and entrepreneurship research" (Klang et al, 2010:9), aiming at becoming an integrative framework of a diversity of concepts and aspects (Klang et al, 2010:10), that includes also value chain analysis, the resource-based view of the firm, strategic network theory, transaction cost economics and aspects of Schumpeterian approach to innovation (Klang et al, 2010:10).

As to BM *components*, Klang et al define each of them as a "building block of the firm's core logic for creating and capturing value" (Klang et al, 2010:12). The list is very long, but a tripartite

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categorization should be retained: there are inside, interface and outside components of a BM (Klang et al, 2010:13). This is why strategic networks for value creation are a relevant part of the BM concept.

As to *configuration*, it deals with the relationships between the BM components. Klang et al (2010) address several views, sometimes rival sometimes potentially complementary: interrelatedness and interdependency; dynamic nature; coherence from the start versus interactive nature of the relationships; sequential nature of the configuration process; narrative approaches versus visual illustrations to explain causal mechanisms; functional perspectives based on the value chain (and not only); design scheme perspective, etc. (Klang et al, 2010:14-15).

Their criticism encompasses the way the three dimensions are addressed, and they identify three major gaps in the literature, which is faulty in regard to: 1) the relationships between BM and domains beyond strategic management and entrepreneurship; 2) the specific industry setting; 3) the fit and coherence of the configurations of the BM (Klang et al, 2010:15-16). In addition, they point out the conceptual fragmentation and lack of theoretical (and empirical) grounding of the concept so far, which is also recognized by Teece (2010).

However, even if it still has a defective nature, the BM concept has become a strong heuristic device to study many new business phenomena like the one we are addressing in our paper. In fact, it provides an integrative framework of approaches and elements; it deals in an adequate way with the relationships between the (porous) current firm and its outside, via transactions, networks, outsourcings and under collaborative and competitive forms; it permits to understand the ways businesses had to adapt and transform to face ongoing technological and societal major shifts (see Chesbrough, 2010).

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3. ANALYTICAL FRAMEWORK

We will draw on business models framework to address our research issue: to analyse the role played by young technology-intensive firms (NTIFs) in the transition to a new energy paradigm in Portugal and more specifically the options and actions they realize to enter in the market and sustain their positioning in there.

Here we explore one of the main dimensions of the business model: the creation of value, the remaining aspects being the subject of a further analysis.

A preliminary issue firms have to deal with is the definition of a value proposition, i.e., "the value created for users by an offering based on technology" (Chesbrough, 2010:355). That offering may assume several forms: a technology; a product; a service; a design; a technical solution; some form of technical assistance and maintenance. A second step consists of targeting a market segment and adopting a competitive approach regarding innovation, differentiation and pricing. Next, the firm has to decide either to produce in-house the whole product (or service) to be released or to resort to external agents, via collaborations, outsourcings, or to market transactions to obtain complementary parts, components and specialized services. In a certain way, this is often not a matter of choice but due to circumstance.

Particularly in the case of small innovative firms dealing with complex and novel technology, they have to specialize in specific segments of the production (or service) process or to remain upstream in the creation and development of technology (ies). In addition, these firms (and small firms in general) are constrained by holding a limited array of internal resources and skills, which propels them to engage realistically in formal and informal connections with selected partners to access the necessary resources. Before addressing the major issue of commercialization – Chesbrough (2010:354) wrote that "the economic value of a technology remains latent until it is commercialized in some way" – these companies have to find financial resources and to design an effective organizational device, where, of course, human resources and leadership are of utmost importance.

The transition to the downstream stage of commercialization consists of a survival test to the NTIFs. If they are not able to overcome this proof they will perish, no matter how good their technology is (see Chesbrough, 2010 on this matter). A recent paper addressed this issue in a comprehensive, systematic and thorough way (Conceição et al, 2012). Finally, the context has to be accounted for. It appears under three different forms: the obstacles and opportunities faced by the firms; the impact of policies; and the behavior of customers, whose role has been transformed as mentioned above.

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Drawing on these contributions, we have built an analytical framework that is briefly presented in table 1. Here we articulate value creation with the analytical dimensions associated with it, decomposed into categories. Finally, we show how we operationalized this framework with a set of built variables used in the questionnaire applied to the firms analysed.

For operational purposes, we will define the business model through the combination of the two major attributes or analytical dimensions: offering definition and business strategy. Together they will define several types of BM, which we will then study empirically according to other relevant dimensions, like innovation strategy, and contextual dimensions such as obstacles and opportunities.

At a later stage we will proceed to the study, not only of value capture, but also of some other relevant analytical dimensions of value creation and context. This paper has for the time being an exploratory nature.

Table 1 - Analytical framework of the Business Model

Theoretical dimensions	Analytical dimensions	Categories
Value creation	Offering definition	Product, technology, services, design, solutions
	Business strategy	Innovation, differentiation, pricing
	Market segment targeted	Niche vs. broad market
	Innovation strategy	In-house Collaborative R&D Basic versus applied research versus experimental development
	Knowledge approach	Nature of knowledge Access vs. creation of knowledge
	Positioning in the value chain	Outsourcing vs. integration Specialization Vertical alliances
	Networks built	Importance of networks to the firms Nature of ties: informal or formal Resources accessed
	Resources and competences mobilized (includes funding)	Human resources Financial resources Equipment, facilities, infrastructure
	Organizational design	Forms
Context	Obstacles vs. opportunities	Types
	Policy measures	Impact Corporate political activity
	Customers behaviour	Preferences Habits Impact Interaction

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4. METHODOLOGY

Data collection

Data were collected through detailed interviews with the companies' founders or CEOs. The interviews were conducted between May and September 2013. They had an average length of 1.5 hours and were supported by a semi-structured questionnaire. The interviewees were asked to provide a brief history of the firm creation and then to give detailed information on the companies' activities and strategies, with emphasis in the processes of development and commercialization of technologies, products or services. Data collected through the interviews was complemented with an extensive search for documentary information on the firms.

Measures

The empirical analysis draws on a set of measures that capture four dimensions of the analytical framework (see table A1 in annex): offering definition, business strategy, innovation strategy and obstacles vs. opportunities.

Regarding the dimension "offering definition", the firms were asked to specify their main current activity, selecting one of the following options: i) commercialize or licence technology; ii) develop and commercialize their own products; iii) integrate their own products with other products; iv) provision of services; v) commercialize third-party products/technologies. Based on this question, two different categories were considered: one includes the development and commercialization of own products or technologies; the other includes the remaining activities.

The questionnaire also included a question about the company's business strategy. The respondents had to choose one of the following options: i) price-based competition; ii) quality/reliability-based competition; iii) technological innovation-based competition; and iv) design/project-based competition.

Regarding the company's innovation strategy, the questionnaire assessed the importance of several innovation practices, using a 7 point Likert-type scale varying from 1 = unimportant to 7 = very important. The innovation practices considered were: i) the introduction of products/services/technologies new to the market; ii) the introduction of products/services/technologies new to the firm; iii) improve significantly the existing products; iv) improve significantly the existing services; v) improve significantly the existing processes; vi) use new or improved commercial forms; vii) develop new or improved forms to organize or manage the energy production/distribution system.

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Finally, the questionnaire addresses the obstacles and opportunities faced by the firms, using the same Likert scale. It includes one question to assess the importance of 12 obstacles and other to assess the importance of six opportunities.

5. EMPIRICAL SETTING

Renewable energies in Portugal

In the last 20 years, Portuguese energy policy has been shaped by the European perspective with the clear purpose of reducing energy dependency and improving energy usage efficiency, whilst respecting environmental concerns and looking towards sustainable development. Since the mid-2000s, several demanding targets for the share of renewables in energy production and consumption were put forward for the EU countries, and the Portuguese government is targeting the ambitious figure of 60% as the share of renewables in electricity production in 2020 (MEID, 2010).

Responding to those targets, the Portuguese government made a strong investment in the production of electricity from renewable sources, using a varied set of policies and incentives: feed-in tariffs, priority access to electricity from renewable energy sources into the grid, fiscal incentives for adoption, public financing (through public investment or grants) and public competitive bidding (REN, 2011).

As a result of the current economic and financial crisis, the energy policy was revised. The government changed the support scheme for renewable energy, with an adjustment of tariffs and the reduction or even elimination of fiscal incentives and public financing. These changes may slow down the development and implementation of renewables, as illustrated by the experience of other countries (Negro and Hekkert, 2010).

Since the mid-2000s it is possible to observe a steady growth of the penetration of renewable energies in the country's electricity production (Figure 1), which in 2011 reached more than 40% corresponding to the third largest value in the EU (Figure 2).

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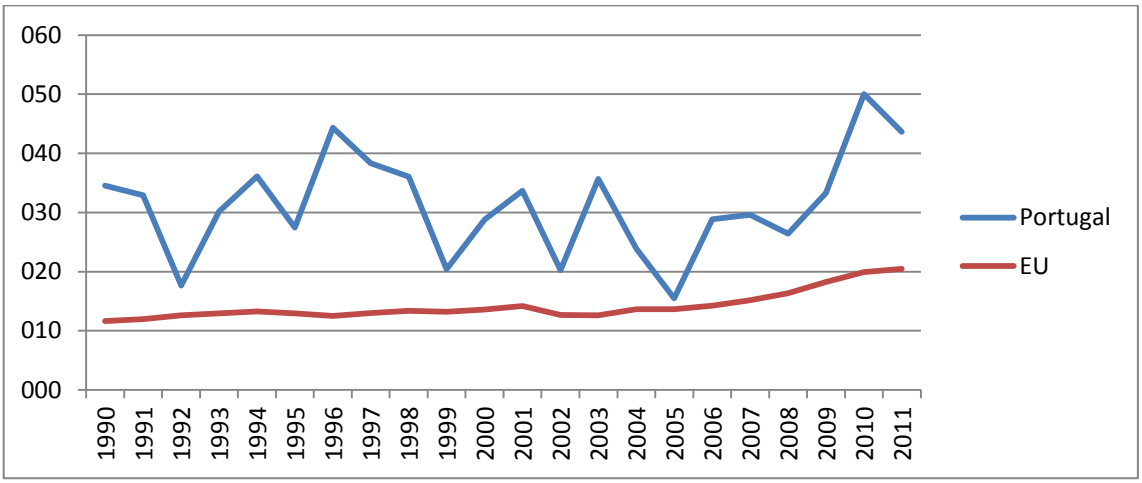
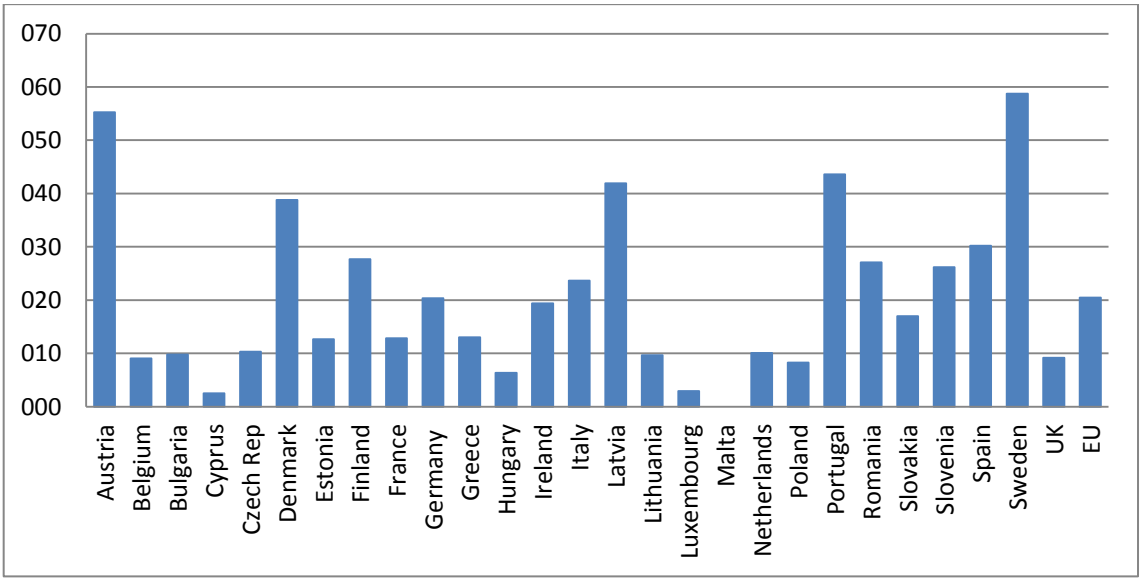
Figure 1 – Electricity generated from renewable sources in Portugal and EU, 1990-2011



Source: Eurostat.

Figure 2 – Electricity generated from renewable sources in EU countries, 2011



Source: Eurostat.

Figure 3 shows the evolution of the electricity generated from renewables by sources, since 1995. It displays the Portuguese enduring tradition in conventional hydropower (> 10MW). This source is characterized by a high volatility, since it is heavily dependent on variations in rainfall and precipitation. That volatility is visible in the Figure 3, which also reveals that a higher penetration of renewable energy sources is mainly based on wind (with an annual growth rate of 53% between 1995 and 2010). Other renewable sources have had a smaller contribution, despite some of them

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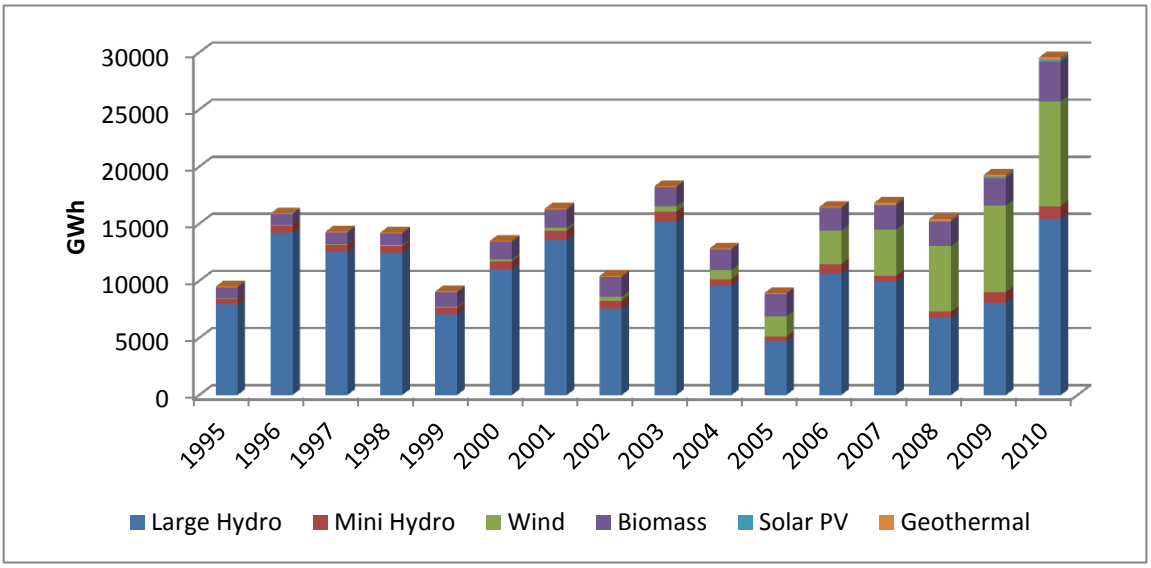
recorded high growth rates. In fact, solar PV registered a high annual growth rate in the period under analysis (48%) (mainly due to the set-up of two large power plants completed in 2007 and 2008), but its contribution remains small (less than 1% of renewables).

Figure 3 - Electricity generated from renewables, by source type

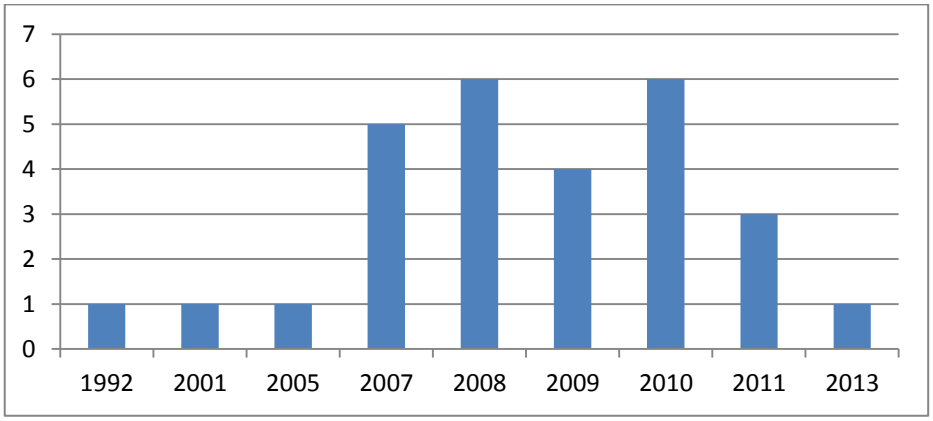


Source: Portuguese National Directorate for Energy (DGEG).

Sample

The empirical analysis of this paper draws on a sample of 28 Portuguese companies. These companies are developing and commercializing renewable energy technologies or products. They are relatively young (75% were created between 2007 and 2010, Figure 4) and are located in three main regions - the Great Lisbon area (42%), Centro, and Norte (21% each). The remaining is dispersed across the rest of the country.

Figure 4 – Year of firm creation



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Most of the companies are very small. In terms of employment (Figure 5), the majority has 10 employees or less, the average number being 8. More than 10% do not have yet any full-time worker. In terms of turnover (Figure 6), the average of the sample is 1.2 million Euros, but most of the firms (78%) had a turnover under 1 million Euros (78%). Four companies are not yet in the market, focusing their activity on the development and test of technology.

Figure 5 – Number of workers, in 2012

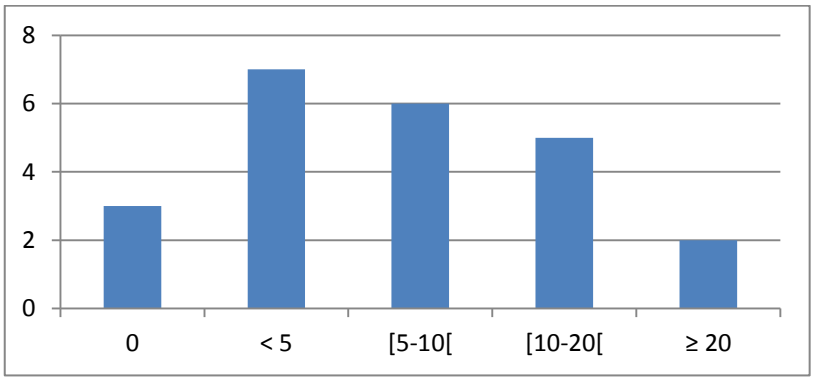
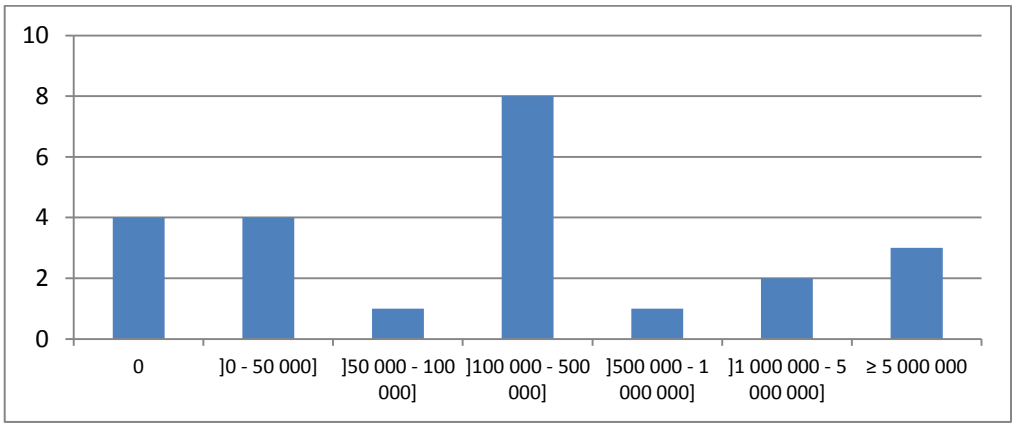


Figure 6 – Turnover, in 2012



More than half of the companies export. The main markets are EU and Portuguese speaking (CPLC) countries. On average, the weight of exports on turnover is 22.5%, but for 18% of the companies exports represent 90% or more of the revenue.

In terms of origin of the company, 68% are spin-offs, either academic (43%) or corporate (25%). The development of the initial renewable energy technology was mainly made in collaboration with other organization (32%), in-house (29%) or was originally developed in the parent organization and then transferred to the company (29%, with 18% transferred formally and 11%

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informally). Only 11% of the companies referred that the initial renewable energy technology was developed by a third-party organization.

The 89% of the companies perform R&D activities, usually combining research (basic or applied) with development (including project or product feasibility or product performance evaluation). However, 18% only perform research activities. In terms of investment, the average percentage in R&D in the 2012 turnover was 43%. When asked if the technology used was applied for patent registration, 57% answered "no", 29% have one patent application and 14% have two patent applications either pending or registered.

6. RESULTS

Business models

As mentioned above, in this paper we consider that BMs can be operationalized combining two dimensions related with value creation: the offering definition and the business strategy. Figures 7 and 8 depict the options made by the companies regarding these two dimensions. A large share of these companies considers the development and commercialization of own products as their main activity (Figure 7). Half of the companies' main activity is developing/selling own products or technologies, while the other half provide services, integrate their own products with third-party products or commercialize third-party products. Regarding the business strategy, the choice of differentiation through innovation is the most frequent situation (Figure 8). None of the companies adopts a strategy based on price competition.

Figure 7 – Offering definition

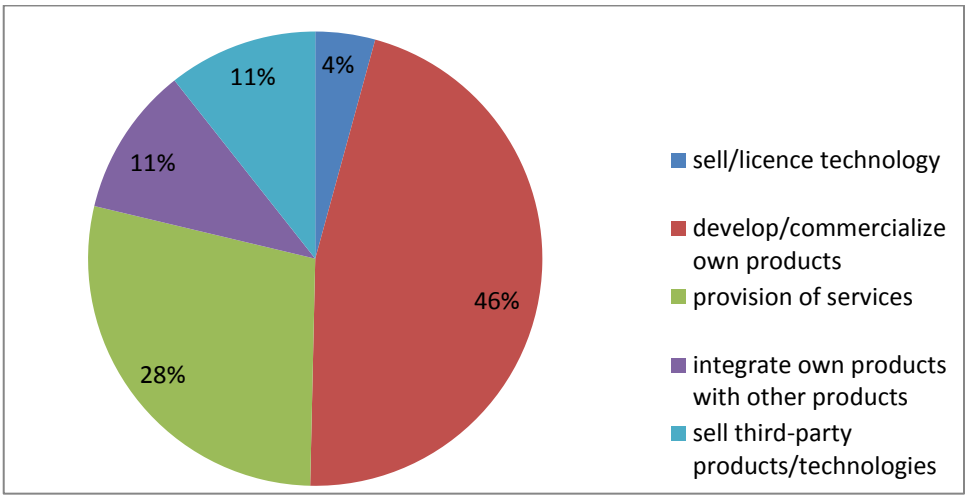

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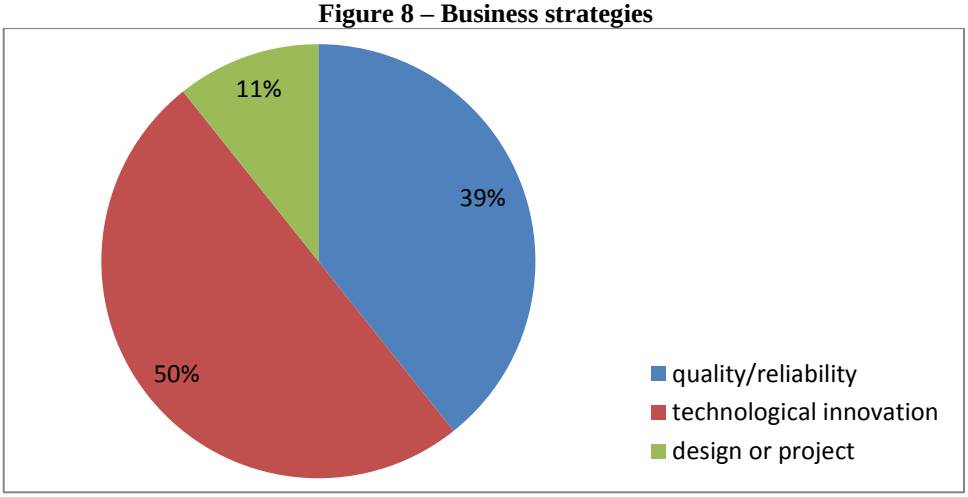
Figure 8 – Business strategies



If we consider both dimensions simultaneously, we have six different possibilities, as shown in Table 2. Since only three companies are following a business strategy based on design/project differentiation and thus the number of cases falling in cells (3) and (6) is very low, we will exclude them in the remaining empirical analysis.

Table 2 – Business models

Business strategy **Offering definition**	**Technological innovation**	**Quality/reliability**	**Design/project**
Development and commercialization of own products or technologies	(1) BM1 10 companies	(2) BM2 3 companies	(3) 1 company
Provision of services, integration of own products, commercialization of third-party products	(4) BM3 4 companies	(5) BM4 8 companies	(6) 2 companies

Therefore, four different business models emerge in these companies:

- Develop own products or technologies based on differentiation by technological innovation – BM1
- Develop own products or technologies based on differentiation by quality/reliability – BM2
- Provide services, integrate or commercialize third-party products based on differentiation by technological innovation – BM3
- Provide services, integrate or commercialize third-party products based on differentiation by quality/reliability – BM4

Table 3 shows the main characteristics of the firms in each business model. Firms adopting the first business model are young and small and often academic spin-offs. Most of them do not export, and in average exports account for 12% of their turnover. All companies perform R&D activities and this group exhibits the higher R&D intensity: companies invest about 85% of their turnover in R&D. Furthermore, companies tend to patent their technologies.

Companies following BM2 show different characteristics. They are often corporate spin-offs and are older and larger than those adopting BM1. In fact, BM2 integrates the largest companies in the

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sample. All companies in BM2 export and exports account for nearly all their sales. Additionally, although all companies carry out R&D activities, its intensity is clearly smaller than that of the companies adopting BM1, not reaching 5% on average. Also the number of companies that patent their technologies is lower, compared to the previous group.

All companies adopting the BM3 are academic spin-offs. This group of companies exhibits the highest average age, but sales are still low (around half a million Euros). Half of the companies export although with a very modest expression. In fact, almost all sales are for the domestic market. The importance of innovation is reflected on the existence of R&D activities all companies, with a strong intensity in terms of turnover, and on the hiring of PHDs.

Table 3 – Firm´s characteristics by business model

Characteristics	BM1	BM2	BM3	BM4
Academic spin-offs (%)	40	33	100	25
Corporate spin-offs (%)	10	67	0	38
Age (average; years)	3.4	6	8.5	4.8
Employees in 2012 (average)	2.1	37.5	8.8	8.6
Turnover in 2012 (average; 10^3€)	62	6800	510	1599
Exporting companies (%)	40	100	50	50
Exports in turnover in 2012 (average; %)	12	96	8	13
Companies with R&D (%)	100	100	100	75
R&D expenses in turnover in 2012 (average; %)	86	3	48	15
Companies with patents (%)	80	67	0	38
Companies with PHDs (%)	0	0	50	13

The BM4 group shows the lowest number of academic spin-offs. Companies are relatively young, but reveal the second largest average turnover. As in the previous group, half of the companies export, but the foreign market has a low expression. This is the only group in which not all companies conduct R&D activities. However, some patent their technologies and/or hire PHDs.

In the remaining of this section we will analyse the differences and similarities across the four business models, considering two dimensions mentioned in the literature and highlighted in our analytical framework: the innovation strategy; and the perception of the context (obstacles and opportunities).

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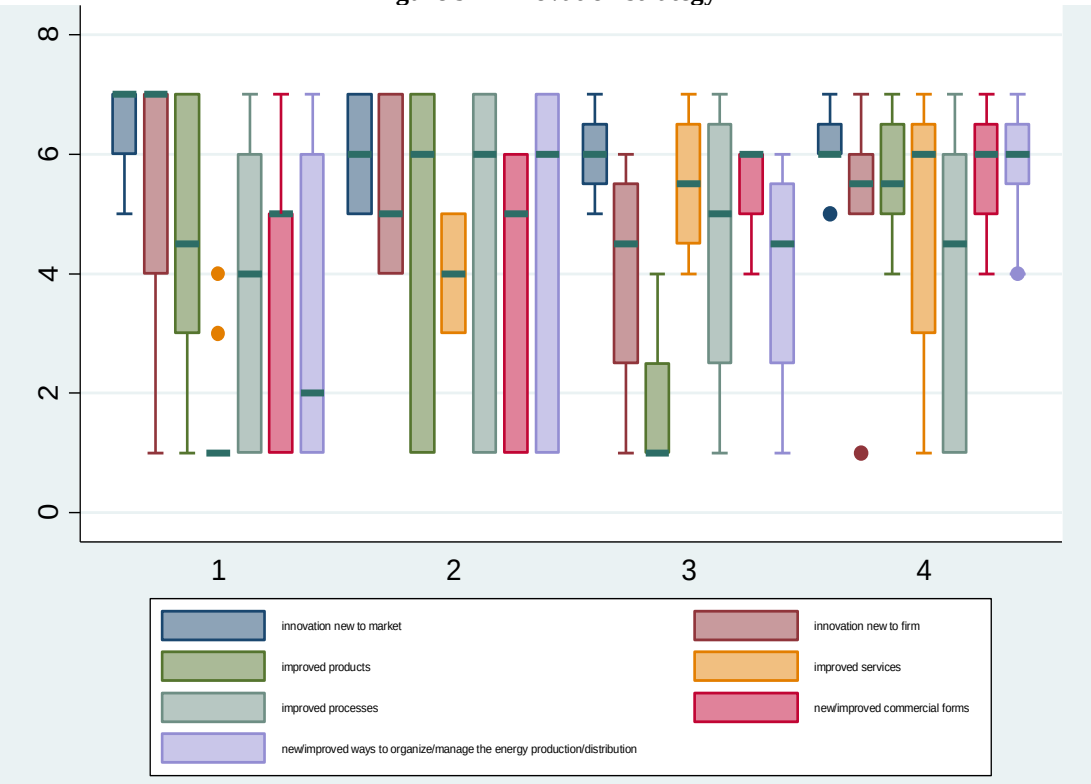
Business models and innovation strategy

According to the literature, the innovation strategy is a relevant aspect of value creation. Thus, we expect that BMs differ in terms of the mix of innovation activities performed by the companies. To capture those differences we have used box plot graphics, since they enable to compare distributions between several groups – in this case the four BMs – using quartiles. The box plot graphic exhibits values for maximum, minimum and median values. It also indicates the degree of dispersion and skewness in the data, and identifies outliers (represented by dots in the graph). Figure 9 shows the box plot for the innovation strategy.

It is possible to observe some regularity across the four groups: in all BMs, companies attribute a high importance to the development of products, services or technologies that are new to the market, since the median is always greater than 5, in a 1-7 scale. The use of new commercial forms is also valued by companies in all BMs (the median is always greater than or equal to 5).

Figure 9 – Innovation strategy



However, we can observe clear-cut differences between the BMs regarding the importance attributed to the distinct innovation activities:

- Companies adopting the BM1 give more relevance (relatively to other groups) to the introduction of new products, services or technologies new to the market or new to the company. At the same time, they attribute low importance to the improvement of existing

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services and to the development of new or improved forms to organize or manage the energy production/distribution system.

- Companies adopting the BM2 are those that value more the activities related with the improvement of existing products or processes.
- Companies adopting BM3 attribute very low importance to activities related with the improvement of existing products.
- Companies adopting the BM4 are those that value more the activities related with the improvement of existing services.

Business models and context perception

In terms of context, we consider both the obstacles and opportunities faced by the companies.

Regarding obstacles (Figure 10), the results show some differences between the four groups of companies:

- For companies in BM1, relatively to other groups, technical risk is a more relevant obstacle, while market risk and the conduct of large energy companies are seen as less important.
- For companies in BM2, relatively to other groups, market risk is a more relevant obstacle, while the non-acceptance of the company's technology by investors or by the civil society is seen as less important.
- For companies in BM3, relatively to other groups, the non-acceptance of the company's technology by the civil society and the conduct of large energy companies are the most relevant obstacles, while the relative cost of the company's technology, the bureaucracy, the reduction of incentives to the adoption of renewables, the access to credit and the macroeconomic conditions are seen as less important.
- Companies in BM4 give more importance (relatively to other groups) to the following obstacles: regulation, fiscal and legal factors, bureaucracy, reduction of incentives to the adoption of renewables and macroeconomic conditions. Conversely, they give less importance to the technical risk obstacle.

Finally, the analysis of Figure 11 also reveals differences across BMs in terms of the perception of opportunities:

- For companies in BM1, relatively to other groups, public incentives and the conduct of large energy companies are less relevant opportunities.
- For companies in BM2, relatively to other groups, technological change and the change in the consumer behaviour are less relevant opportunities.

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- For companies in BM3, relatively to other groups, the emergence of new markets is a less relevant opportunity.
- For companies in BM4, relatively to other groups, the emergence of new markets and the conduct of large energy companies are more relevant opportunities.

Figure 10 - Obstacles

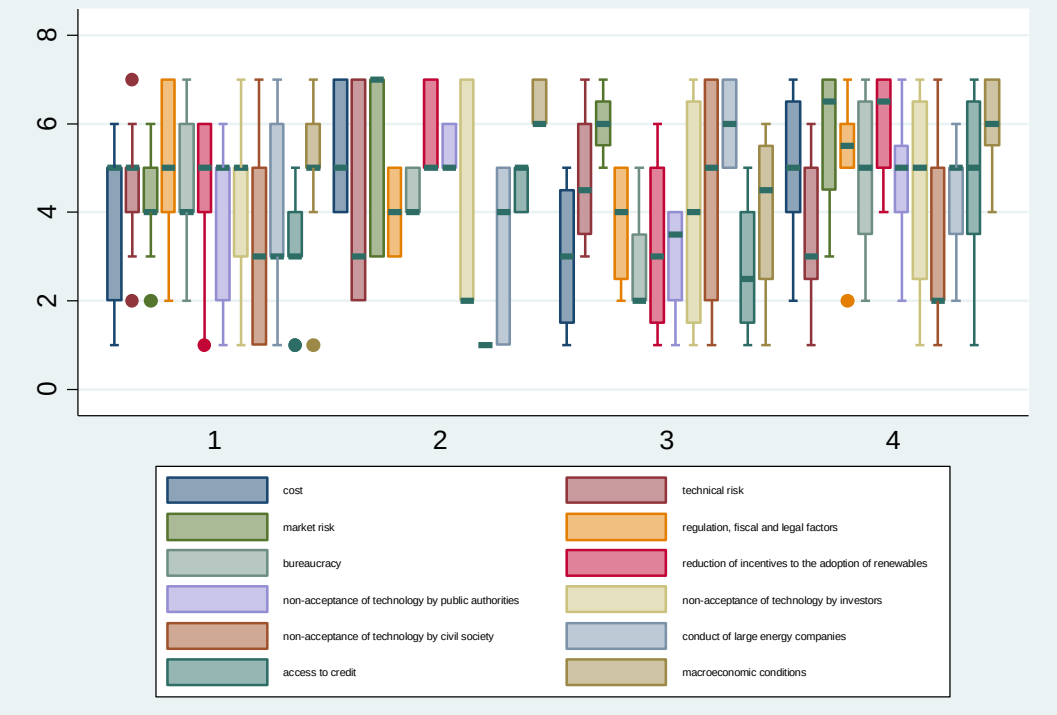
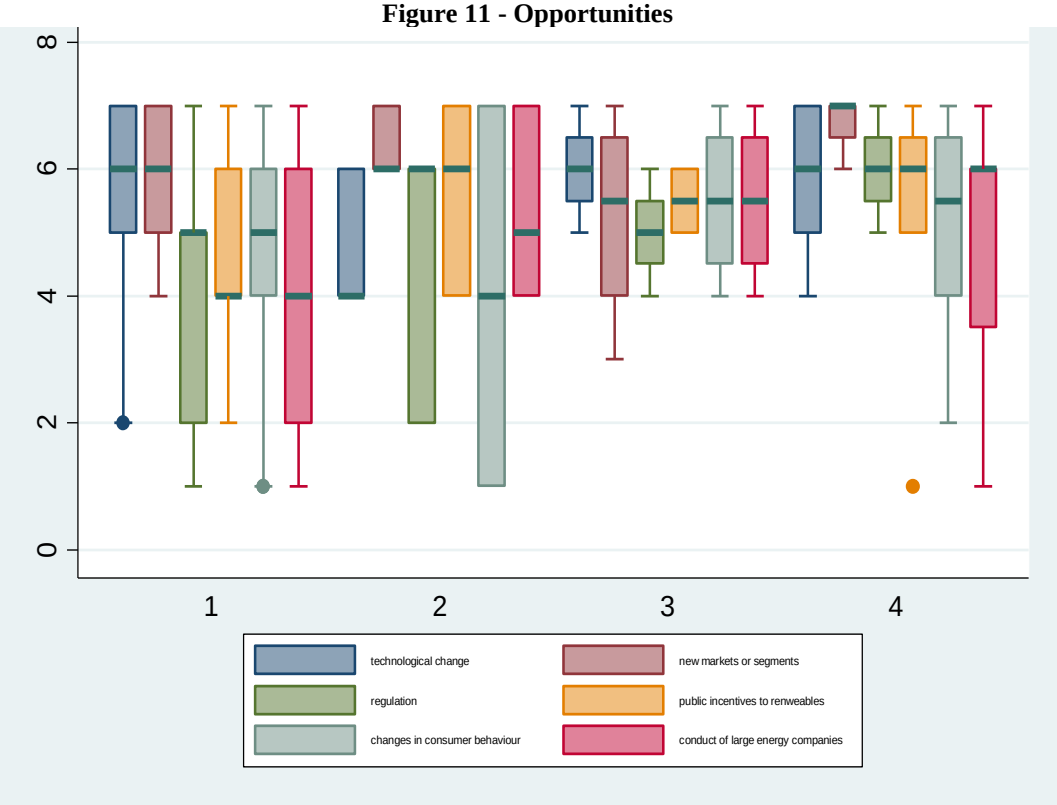


Figure 11 - Opportunities



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7. CONCLUSION

This exploratory study based on a sample of 28 new technology-intensive firms operating in new energy technologies is still at a preliminary stage. However, some conclusions and insights for future research may be drawn.

First, we have suggested an approach to the firms' behaviour based on the business model concept. This framework permits to integrate a diversity of analytical dimensions that contribute to the understanding of value creation and value capture by the firms, embedded in a context moulded by policy and involving obstacles and opportunities. This framework appears as a fruitful heuristic device, although it is generally recognized in the literature that it is still to be extended and improved, through both theoretical and empirical work.

Using this framework, we were able to find the existence of four different business models in the group of firms. These business models were built according to two major dimensions, the main activity of the company (i.e. the definition of its main offering, technology, product or service) and the business strategy (innovation oriented or quality oriented). With this typology we studied how firms conduct their innovation strategy and perceive the obstacles and opportunities put to them. We found quite contrasted patterns across the four business models, which seems to indicate that this kind of demarche is useful to understand how NTIFs act in the respective markets.

Further research will integrate other dimensions regarding value creation and will address value capture, not considered empirically in this paper. In addition, we will extend the sample and will explore more thoroughly the patterns observed, resorting to more sophisticated techniques.

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ANNEX

Table A1 – Description of the variables

Dimension	Variable	Description	Values
Offering definition	Commercialization or licensing of technology	The main current activity of the company is to commercialize or to licence technology	Binary 1=yes; 0=no
	Development and commercialization of own products	The main current activity of the company is to develop and commercialize their own products	Binary 1=yes; 0=no
	Integration of own products with those of third parties	The main current activity of the company is to integrate their own products with other products	Binary 1=yes; 0=no
	Provision of services	The main current activity of the company is to provide services	Binary 1=yes; 0=no
	Commercialization of third-party products/technologies	The main current activity of the company is to commercialize third-party products/technologies	Binary 1=yes; 0=no
Business strategy	Price-based competition	The business strategy of the company is based on price competition	Binary 1=yes; 0=no
	Quality/reliability-based competition	The business strategy of the company is based on the quality or reliability of products/services/ technologies	Binary 1=yes; 0=no
	Technological innovation-based competition	The business strategy of the company is based on technological innovation	Binary 1=yes; 0=no
	Design/project-based competition	The business strategy of the company is based on the characteristics of the design/project	Binary 1=yes; 0=no
Innovation strategy	Innovation new to the market	Importance attached to the development and commercialization of products, services or technologies that are new to the market	Likert scale 7 = Extremely important; 1= Not important at all
	Innovation new to the firm	Importance attached to the development and commercialization of products, services or technologies that are new to the company	Likert scale 7 = Extremely important; 1= Not important at all

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	Improvement of existing products	Importance attached to a significant improvement of existing products	Likert scale 7 = Extremely important; 1= Not important at all
	Improvement of existing services	Importance attached to a significant improvement of existing services	Likert scale 7 = Extremely important; 1= Not important at all
	Improvement of existing processes	Importance attached to a significant improvement of existing processes	Likert scale 7 = Extremely important; 1= Not important at all
	New commercial forms	importance attached to the development and use of new commercial forms	Likert scale 7 = Extremely important; 1= Not important at all
	New or improved forms to organize or manage the energy production/distribution system	Importance attached to the development of new or improved forms to organize or manage the energy production/distribution system	Likert scale 7 = Extremely important; 1= Not important at all
Obstacles	Cost	Importance attached to the relative cost of the company's technology as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Technical risk	Importance attached to the technical risk as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Market risk	Importance attached to the market risk as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Regulation, fiscal and legal factors	Importance attached to regulation, fiscal and legal factors as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Bureaucracy	Importance attached to bureaucracy as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Reduction of incentives to the adoption of renewables	Importance attached to the reduction of incentives to the adoption of renewables as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Non-acceptance of technology by public authorities	Importance attached to the non-acceptance of technology by public authorities as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Non-acceptance of technology by investors	Importance attached to the non-acceptance of technology by investors as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all

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	Non-acceptance of technology by the civil society	Importance attached to the non-acceptance of technology by the civil society as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Conduct of large energy companies	Importance attached to the conduct of large energy companies as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Access to credit	Importance attached to access to credit as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all
	Macroeconomic conditions	Importance attached to macroeconomic conditions as an obstacle for the company's business and the pursuit of its strategic goals	Likert scale 7 = Extremely important; 1= Not important at all

Opportunities	Technological change	Importance attached to technological change as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	New markets or segments	Importance attached to the emergence of new markets or segments as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	Regulation	Importance attached to regulation as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	Public incentives to renewables	Importance attached to public incentives to renewables as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all
	Favourable conduct of large energy companies	Importance attached to the conduct of large energy companies as a source of opportunities for the company	Likert scale 7 = Extremely important; 1= Not important at all

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